Approved in 44th BoA Meeting (24-11-2021)

Course number : ET 502
Course Name : Embedded Systems and IoT for E-Transportation
Credit Distribution : 3-0-2-4
Prerequisite : Digital System Design (EE210) or equivalent
Intended for : PG
Distribution : Core for M.Tech in Electric Transportation students, elective for other advanced B.Tech /M.Tech students
Mutual Exclusion : NA

Preamble: The mainstream electric transportation is a promising technology that has evolved in the 21st century to provide a clean, green alternate mode of transportation in contrast to emissive vehicles that are highly dependent on fossil fuels, emit greenhouse gases and have poorer energy efficiency. Providing a safe, reliable, lightweight and efficient on-board electrical energy source, as well as the required charging infrastructure are the main challenges in electric transportation. Embedded Systems play a major role in electric vehicles where embedded systems form an integral part of the battery management system. The hardware part deals with cell monitoring, charge control, thermal management, and cell balancing. The software part with algorithms to estimate the state of charge and state of health provides accurate information about the internal state of the battery to the hardware parts, driver, and energy management units. In order to provide an efficient charging system, abilities of IoT to demonstrate the ubiquitous perception and the real-time interactive view in the smart grid system need to be explored. The proposed course aims at building up an in depth understanding among the advanced B.Tech / M.Tech / M.S./ Ph.D students of embedded systems and IoT and its role in electric transportation through a perfect synergy of class lectures and hands-on assignments.

Course content:

1. Introduction to embedded systems: Understanding an embedded system, design metrics, design challenges, technologies for embedded systems. (2 hours)
2. Custom Single Purpose Processor for Embedded Systems: Design of data-paths and controllers, finite state machines, custom single purpose processor design at RT level, optimizing custom single purpose processors, introduction to hardware description languages, modeling of custom single purpose processors using hardware description languages. (3 hours)
3. Introduction to FPGA: Introduction to complex digital systems design, notion of programmable logic devices, overview of FPGA architecture, realization of data-path and controller, timing analysis of data-path and controller, synthesis, placement, routing, performance optimization. (2 hours)
4. Introduction to Microcontrollers: Introduction to microcontrollers, overview of architecture of a typical microcontroller such as AVR microcontroller, addressing, assembly language programming, Memory and I/O interfacing, device drivers for I/O devices. (4 hours)

5. Sensors and Actuators: Basic principles of sensors and actuators, classification of sensors and actuators, interface methodology and circuits, integration aspects (3 hours)
6. Embedded Systems for Electric Transportation: Battery management system (BMS), cell monitoring, battery safety and protection, state of charge estimation, state of health estimation, cell balancing, thermal management, charging control, BMS architectures. (8 hours)
7. Introduction to IoT: Overview of Internet of Things, IoT architecture, Communication protocols (4 hours)
8. Protocols for Wired communication: Device configuration and protocols, e.g., CAN, LIN, FlexRay, MOST, Ethernet, OBDII, (5 hours)
9. Protocols for Wireless communication: Wifi, ZigBee, Bluetooth Low Energy (BLE) (5 hours)
10. IoT for Electric Transportation: Centralized charging scheme, decentralized charging scheme, performance comparison and evaluation. (6 hours)

Experiments for lab: 28 hours

1. Hardware modeling using hardware description language
2. Modeling a custom single purpose processor for electric vehicle applications
3. Hardware realization using FPGA
4. Interrupt handling through microcontroller
5. Stepper Motor control using microcontroller
6. Battery management using microcontroller
7. FPGA based battery management architectures
8. Designing a multiprotocol system
9. Wired communication using CAN bus, LIN, FlexRay, MOST, Ethernet, OBDII
10. TCP-UDP client server systems
11. IoT application layer protocols - MQTT-CoAP
12. Applications of IoT on centralized charging scheme
13. Applications of IoT in decentralized charging scheme

Text books:

1. Rui Xiaong, Weixiang Shen, "Advanced Battery Management Technologies for Electric Vehicles", Wiley publishers, 2019.
2. James K. Peckol, "Embedded Systems: A Contemporary Design Tool", Wiley publishers, 2009.

Reference books:

1. Peter Xiao, "Designing Embedded Systems and the Internet of Things (IoT) with the ARM mbed", Wiley publishers, 2018.
2. Edward Ashford Lee and Sanjit Arunkumar Seshia, "Introduction to Embedded Systems – A Cyber–Physical Systems Approach", MIT Press, 2017.
3. Charles H. Roth Jr., Lizy Kurian John, "Digital Systems Design Using VHDL", Cengage Learning, Third Edition, 2016.

Similarity content declaration with existing courses:

Sl. No.	Course Code	Similarity Content	Approx. % of content
01.	EE529	Introduction to FPGA, Introduction to microcontrollers	14%
02.	EE536	Protocols for wireless communication	12%

Justification of new course proposal if cumulative similarity content is >30%:

Indian
Institute of
Technology
Mandi